RESEARCH ARTICLE

POLYGLUTAMIC ACID-INFUSED LIP GLOSS: ENHANCING SHINE WITH NON-STICKY HYDRATION

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Abstract:

Lip glosses are widely used for their instant shine and colour appearance however, traditional formulations often lack enough hydration and often feel sticky. This study aimed to develop a lip gloss enriched with polyglutamic acid (PGA), a biopolymer with strong water-binding properties, to achieve both high shine and non-sticky moisturization. Water-in-oil emulsions were formulated with PGA at 3% w/w using Hydrocarbon gel as the gelling base, polysorbate 80 as emulsifier, and cosmetic grade pigments for colour. Three PGA formulations (F1–F3) were prepared along with a control (C). The optimized formulation (F3, 3% PGA) was evaluated through sensory analysis on 10 healthy volunteers for physical appearance, gloss, spreadability, hydration, stickiness, and overall acceptability. Spreadability was also measured via the glass-slide method. Results showed PGA-enriched gloss had a smooth texture, uniform shine, better hydration, and felt less sticky this shows that PGA is useful ingredient that makes lipgloss nice in appearance and good for lip care

Keywords: Polyglutamic Acid, Lip Gloss, Hydration, Non-Sticky, Cosmetic Formulation, Humectant.

Introduction:

Recently lip care products like lipgloss have become very popular because it makes lips shine and colourful even though heir aesthetic appeal, traditional lip glosses often face complains for being sticky, heavy, and providing limited hydration, which can affect overall user comfort and satisfaction (Bodhankar, 2022) Modern consumers now prefer multifunctional cosmetics that combine beauty with care, seeking products that offer both visual appeal and effective moisturization (Azmin *et al*., 2020; Joshi *et al*., 2024).

Polyglutamic acid (PGA), a naturally occurring polypeptide composed of glutamic acid units, has recently gained attention as a potent humectant and film-forming agent in cosmetic formulations.

Its remarkable water-binding capacity allows it to retain moisture more effectively than some traditional humectants, such as hyaluronic acid, while forming a smooth, protective layer on the skin or lip. (Serra *et al*., 2024; Urai *et al*., 2015) PGA biocompatibility, biodegradability, and non-sticky nature make it particularly suitable for lip gloss formulations where both comfort and sensory experience are critical (Tao *et al*., 2021; Drakontis & Amin, 2020).

Including PGA into lip gloss is expected to enhance hydration, reduce transepidermal water loss (TEWL), and provide a smooth, non-sticky finish without compromising shine. This study focuses on developing and evaluating a PGA-enriched lip gloss aimed at delivering high gloss, effective moisturization, and overall user satisfaction. By exploring the effects of varying PGA concentrations, this work seeks to establish PGA as a multifunctional ingredient helps lipgloss be attractive and good for lip care at the same time (Jangdey *et al*., 2014; Johnson *et al*., 2022).

Materials and Methods:

1. Chemicals and Reagents

- PGA, cosmetics grade: added at 1%, 2%, and 3% w/w
- Hydrocarbon gel: Oil-soluble gel base providing gloss and structure
- Polysorbate 80: Used as an emulsifier
- Oil-soluble cosmetic pigments: For color and appearance
- Essential oils: for fragrance.
- Phenoxyethanol (0.5% w/w): Preservative.
- Distilled water: Used in aq phase

All chemicals are of cosmetic or analytical grade and taken from the department's stock

2. Equipment

Analytical balances, glass beakers, hot plate with magnetic stirrer, water bath, high-shear homogenizer, spatulas, pipettes, thermometer, glass slides, and airtight containers

3. Formulation of Lip Gloss

Table 1: Formulation and Development of Lip Gloss Formulations with PGA (100 g Batch Size)

Component (g/100 g)	**Control (C)**	**F1 – PGA 1%**	**F2 – PGA 2%**	**F3 – PGA 3%**
Hydrocarbon gel	83	83	82	80
Oil blend	6	6	5	4
Pigments	1	1	1.5	1.5
Vitamin E	1	1	0.5	0.5
Fragrance / Essential oils	0.2	0.2	0.5	0.5
Polysorbate 80	1	1	2.0	2.0
Distilled water	10	9	8	7
Polyglutamic acid (PGA)	–	1.0	2.0	3.0
Preservative (phenoxyethanol)	O.5	0.5	0.5	0.5
Total	100.0	100.0	100.0	100.0

- PGA was firstly dissolved in water and then mixed with polysorbate 80 before adding to the gel base
- Formulations F1, F2, F3 used increasing amount of PGA to check hydration and how sticky they felt
- In control sample all ingredients are there expect PGA

Preparation of Lip Gloss Formulations

The preparation of three lip gloss formulations was done F1, F2, F3 with different amount of PGA in it along with control (C) without PGA the formulation was made using a two phase method as described below (Bodhankar, 2022; Drakontis & Amin, 2020).

Aqueous Phase:

PGA was weighed and dissolved in distilled water and Phenoxyethanol (0.5% w/w) was added as a preservative. The mixture was stirred continuously until a clear solution was obtained This ensured complete dissolution of PGA and even distribution of the preservative. (Serra *et al*., 2024; Urai *et al*., 2015).

Oil Phase:

Hydrocarbon gel was heated to 70–75 °C in a water bath. Oil-soluble pigments were added to this warm gel, and, where applicable, polysorbate 80 was added as an emulsifier. The mixture was stirred continuously until the pigment and emulsifier blended evenly (Azmin *et al*., 2020; Jangdey *et al*., 2014).

Emulsification:

The aqueous solution was slowly added into the oil phase with continuous stirring. A homogenizer was run for 5–10 minutes to get a smooth gel without separation. (Joshi *et al*., 2024)

Cooling and Finalization:

The emulsion was allowed to cool to room temperature. Fragrance was added when the temperature was below 40 °C The final lip glosses was then filled in containers, labeled with their codes (C, F1–F3), kept and store for testing (ICH, 2003)

Figure 1: Final optimized lip gloss formulation (F3, 3% PGA) showing smooth texture and uniform gloss

- F1, F2, and F3 represent formulations with increasing PGA concentrations to assess hydration and non-stickiness.
- The control (C) contains all ingredients except PGA and serves as the baseline for comparison.
- Stirring and temperature was kept constant to make sure the formulations stayed uniform

4. Evaluation of Formulations

4.1 Physical Appearance and Texture

The colour, and smoothness of the formulations was uniform and smooth. The PGA glosses (F2 and F3) was little shinier and more even compared to the control (Bodhankar, 2022).

4.2 pH

The pH of each lip gloss was measured by mixing 1 g of the sample with 100 ml water. Three readings were taken with a digital pH meter, and the average was recorded (Azmin *et al*., 2020; Joshi et al., 2024).

4.3 Spreadability

A fixed amount of lip gloss was placed between two glass slides, and the spread diameter was measured (F2 and F3) showed higher spreadability (average 4.0 ± 0.4 cm) than the control, indicating smooth flow and easy application (Jangdey *et al*., 2014).

4.4 Gloss / Shine (Sensory Assessment)

Ten healthy women aged 20–30 tried the gloss right after applying it. They gave a score from 1 to 5, where 1 meant dull and 5 meant very shiny. (Azmin *et al*., 2020; Joshi et al., 2024)

4.5 Hydration / Moisturization (Sensory Assessment)

Volunteers checked how hydrated their lips felt right after applying the gloss. They gave a score from 1 (not hydrated) to 5 (very hydrated). F3, which had PGA, felt more moisturizing than the control (Azmin *et al*., 2020; Joshi *et al*., 2024).

4.6 Stickiness (Sensory Assessment)

Volunteers rated how sticky the gloss felt right after applying it, from 1 (not sticky) to 5 (very sticky). F3 was found to be the least sticky, showing that PGA makes the gloss feel smoother while keeping it moisturizing (Azmin *et al*., 2020; Joshi *et al*., 2024).

4.7 Overall Acceptability (Hedonic Scale)

Volunteers rated how much they liked the gloss on a scale from 1 (very dissatisfied) to 5 (very satisfied), considering shine, comfort, moisturization, and stickiness. F3 got the highest score, showing it was the most liked formulation overall (Li, Zhang, & Wang, 2022)

5. Evaluation of Followiings

5.1 Volunteer Details

Ten healthy female volunteers aged 20–30 years participated in the sensory evaluation. Volunteers provided informed consent prior to the study

5.2 Sensory Evaluation Procedure

Volunteers were given coded samples of Control, F1, F2, and F3 in random order. A small, fixed amount of each gloss was applied on their lips. They rated gloss, spreadability, hydration, stickiness, and overall liking using prepared score sheets. The average scores were calculated to find

the best PGA-enriched lip gloss, which was F3 (3% PGA) based on overall sensory performance. (Azmin *et al*., 2020; Joshi *et al*., 2024).

5.3 Stability Study

The best lip gloss, F3 (3% PGA), was tested for stability. It was stored at room temperature (25 °C), in the fridge (4 °C), and at a higher temperature (40 °C) for 30 days. Colour, separation, smell, texture, and gloss were checked on days 0, 8, 16, and 30. It was also centrifuged at 3000 rpm for 15 minutes to test stability under stress. F3 kept its properties in all conditions, showing good short-term stability (ICH, 2003)

Results:

1. Physical Appearance and Texture

All formulations looked uniform and had a smooth texture. The control (C) and F1 were slightly less glossy, while F2 and F3 were more uniform and smooth. No phase separation or colour changes were seen when stored at room temperature for 7 days.

2. pH

The pH values of the lip gloss formulations are shown in Table 2. They ranged from 5.2 ± 0.2 for the control to 5.6 ± 0.2 for F3, which is close to natural lip pH. The PGA-containing formulations had slightly higher pH

Table 2: pH values of different lip gloss (Trials) formulations

Formulation	pH Value (Mean ± SD)
Control (C)	5.2 ± 0.2
F1 – PGA 1%	5.4± 0.1
F2 – PGA 2%	5.5 ± 0.1
F3 – PGA 3%	5.6± 0.2

3. Spreadability (Glass-Slide Method)

The average spread diameter of the lip gloss formulations was 4.5 ± 0.2 cm, indicating smooth flow and uniform application PGA-enriched formulations (F2 and F3) spread more evenly than control, supporting ease of application and desirable texture

4. Sensory Evaluation

Sensory evaluation was conducted on 10 healthy female volunteers scores for gloss, spreadability, hydration, stickiness, and overall acceptability are presented in Table 3

Table 3: Sensory Scores of Lip Gloss Formulations

Parameter	Control (C)	F1 – PGA 1%	F2 – PGA 2%	F3 – PGA 3%
Gloss	3.2	3.5	4	4.5
Spreadability	3	3.2	3.6	4
Hydration	2.8	3.5	4	4.6
Stickiness	4.2	3.8	2.8	2
Overall Acceptability	3	3.5	4	4.5

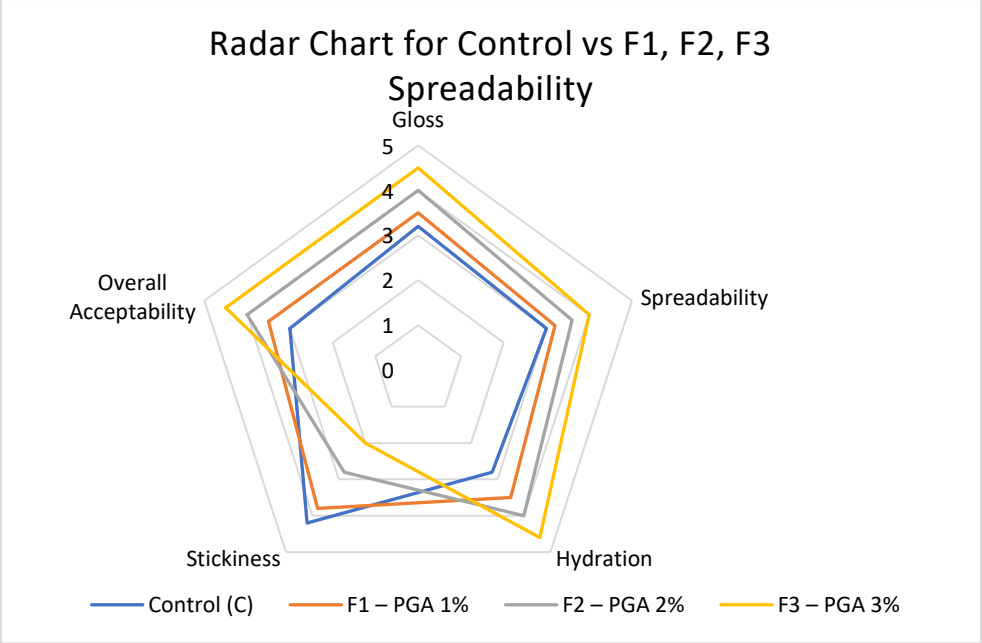

Figure 2: Comparative Radar Chart of Sensory Evaluation Parameters for Control and PGA Formulations

*Lower stickiness score indicates less sticky feel

Observations:

- Gloss and Shine: Increasing PGA concentration improved visual shine. F3 (3% PGA) received the highest gloss score.
- Spreadability: F3 spread smoothly without dragging, while control and F1 felt slightly thicker during application.
- Hydration: PGA-enriched formulations retained higher moisture, with F3 achieving the maximum score (4.6 ± 0.3)
- Stickiness: Incorporation of PGA reduced sticky feel; F3 was the least sticky
- Overall Acceptability: F3 was most preferred due to the combination of high gloss, smooth spreadability, hydration, and minimal stickiness

5. Selection of Optimized Formulation

Based on the overall sensory scores, F3 (3% PGA) was the best formulation, showing the most hydration, least stickiness, and best visual appeal.

6. Short-Term Stability of Optimized Formulation (F3, 3% PGA)

The optimized formulation kept its physical and sensory properties over 30 days, with no changes in color, separation, smell, texture, or gloss.

Table 4: Short-Term Stability Observations of Optimized Lip Gloss Formulation (F3, 3% PGA)

Parameter	**0 day**	**8days**	**16days**	**30 days**
Color	No change	No change	No change	No change
Phase separation	None	None	None	None
Odor	No change	No change	No change	No change
Texture / Gloss	Stable	Stable	Stable	Stable

Observation:

These results show that F3 (3% PGA) is stable and keeps its desired cosmetic properties when stored under normal conditions.

Discussion:

This study aimed to make a lip gloss that is shiny yet non-sticky and moisturizing by using polyglutamic acid (PGA). Regular lip glosses look good but are often sticky and do not hydrate well, which can be uncomfortable. PGA, a natural polypeptide that holds water and forms a film, was expected to improve both hydration and the overall feel of the gloss.

pH

The pH values of all formulations were within the range suitable for lip application, reflecting compatibility with the natural pH of the lips. A slightly increase in pH was observed with increased concentrations of PGA, which may be because of its natural alkalinity. Keeping the pH at the right level helps the product stay stable, keeps its colour intact, safe to use on the skin, and reduces the chance of microbial growth.

Spreadability

The lip gloss showed good spreadability as evaluated by both the glass-slide method and the 5-point rating scale The glass-slide test indicated smooth flow and uniform coverage, suggesting that the formulation possesses a desirable texture and maintains consistent performance.

Gloss and Shine

The sensory test showed that the PGA lip gloss felt smoother and looked more even than the control. PGA probably forms a thin layer on the lips that holds water, making them shiny without feeling sticky. This matches what other studies have found, that such ingredients can make lip gloss look and feel better.

Hydration and Moisturization

PGA's ability to hold water probably helped improve the hydration felt by volunteers. F3 made the lips feel much more moisturized than the lower-concentration glosses and the control, showing that PGA helps keep lip moisture and reduces water loss. This agrees with earlier studies showing that PGA can hold moisture better than traditional ingredients like hyaluronic acid.

Stickiness

The volunteers found that F3 was the least sticky compared to the control. The non-sticky feel of the PGA gloss is likely because PGA attracts water but doesn't make the lips tacky. This shows that PGA can both hydrate and keep the gloss smooth, making it a useful ingredient for lip products.

Overall Acceptability

Volunteers liked F3 the most overall, showing that the combination of shine, hydration, and smooth feel makes the gloss more enjoyable to use. PGA successfully combines good looks with lip care, meeting the need for products that do both.

Stability

F3, was tested for 30 days at room temperature, in the fridge, and at higher temperatures. It showed no separation, colour change, or changes in texture, shine, or smell, indicating it stayed stable.

Additional stress tests confirmed it remained uniform and intact. This shows that adding PGA does not affect stability and makes the gloss practical to use.

Formulation Optimization

Three lip glosses with increasing PGA amounts (1%, 2%, and 3%) were tested along with a control. The best one, F3 (3% PGA), had the most desirable qualities highest shine, better spread, more hydration, and least stickiness. This shows that PGA improves lip gloss performance in a concentration dependent way. Lower amounts (F1 and F2) gave some improvement but didn't match the overall benefits of F3.

Limitations and Future Perspectives

While the sensory tests give useful insights, using instruments to measure gloss and hydration (like a glossmeter or corneometer) could provide more solid evidence. Also, testing the gloss for longer periods, trying different PGA amounts, or combining it with other moisturizing ingredients could help make the formulation even better.

Conclusion:

In conclusion, this study shows that 3% PGA is effective in making a lip gloss that looks good, keeps lips hydrated, non-sticky and stays stable. These results highlight PGA as a useful ingredient for modern lip products, meeting consumer demand for cosmetics that combine both beauty and care.

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